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Abstract

Agriculture is a major source of global greenhouse gas emissions and therefore effective policy interventions are required in order to mitigate these emissions. One form of intervention used within the agricultural sector is participatory extension programmes (PEPs). PEPs are advisory programmes based on voluntary participation where farmers, researchers, and rural experts collectively learn by sharing information and experiences. To evaluate the contribution of these programmes towards more climate friendly farming, this paper conducts an *ex-post* evaluation of a PEP focused on the voluntary uptake of on-farm emissions mitigation practices in the UK. We use a mixed-methods approach to understand both the adoption of new practices and a range of human-social outcomes such as social learning, resilience and improved decision-making. We find that participants in the PEP show a higher level of practice adoption compared to non-participants. However, the evaluation of the human-social indicators shows that the change cannot always be attributed to PEP participation. The paper contributes to the current literature by conducting the first evaluation on a climate change PEP in a developed country and by developing and applying an effective evaluation framework for climate change PEPs, in order to achieve an understanding of the change achieved by PEPs.

Key words: climate change, agriculture, extension programme, evaluation, mixed-methods

1. Introduction

Agriculture is directly and indirectly responsible for approximately 25% of global greenhouse gas (GHG) emissions (IPCC 2014; Le Quéré et al. 2016), and there is an increasing interest in ways to manage emissions caused by farm level practices (Olander et al. 2014). Although a range of interventions and practices have been developed (Black 2000), implementing these is complex due to the biophysical, economic and behavioural heterogeneity of farms. To date, attempts to stimulate the uptake of climate friendly practices in Scotland have mainly been delivered through voluntary programmes seeking to reduce emissions while maintaining farm profits. One approach to promoting these mitigation practices is via participatory extension programmes (PEPs), a type of advisory service, in which farmers, researchers and rural experts collectively learn by sharing information and experiences (Black 2000).

Given the public investment in PEPs, and their uncertainty around the potential contribution to achieving environmental targets, it is important that these programmes are reliably evaluated (Klerkx, Landini and Santoyo-Cortés 2016; Faure, Desjeux and Gasselin 2012). EU member states have set up evaluation guidelines for their Rural Development Programmes, including recommendations on mixed-methods (European Commission 2010; European Commission 2015). However, while a lot of these evaluations have probably been conducted within the EU, limited work has been reviewed and discussed in scientific literature. The evaluations that have been published in peer-reviewed literature have mainly been conducted in developing countries; predominantly financial and productivity indicators have been used to identify the monetary return on investment (Läpple and Hennessy 2015; e.g. Läpple, Hennessy and Newman 2013); only a limited set of studies have applied qualitative or mixed methods to evaluate the effectiveness of programmes (Jones, Glenna and Weltzien 2014; Prager and Creaney 2017); and no study has evaluated agri-environmental PEPs to identify the contribution towards climate friendly farming.

To address this knowledge gap, this paper applies a mixed-methods approach to evaluate the effectiveness of an agri-environmental PEP in Scotland, focusing on environmental indicators and human-social aspects, i.e. social learning, resilience, and management skills. The paper adds to the current literature by conducting an evaluation on a climate change PEP in a developed country context by developing and applying an evaluation framework to gain understanding in the potential change achieved by such PEPs. In the following subsections we introduce PEPs and current literature regarding their evaluation.

1.1 Participatory extension programmes

PEPs first emerged as an alternative to the linear top-down 'transfer of technology' model in the 1960s in Australia and New Zealand (Braun and Duveskog 2011; Millar 2011; Parminter 2011). In this model researchers developed and validated new technology, extension agents communicated this to farmers, who then adopted these new technologies (Black 2000). However, in the 1980s the approach received various critiques, such as: failing to account for local complexity; lacking a farmers' perspective (Pretty 1995); failing to account for knowledge in the development and dissemination of practices (Pretty and Chambers 1993); and not providing sufficient return on investment (Feder, Willett and Zijp 1999). Participatory extension in the agricultural sector has so far shown to be a success due to its association with: high rates of practice adoption; a positive impact on productivity and income; an increase in knowledge and skills; and good availability of peer support (Davis et al. 2012). After Australia and New Zealand, participatory extension also became widely applied in developing countries as 'farmer field schools' (Braun and Duveskog 2011), and in European countries as farmer led discussion groups and innovation platforms (Knook et al. 2018).

PEPs aim to create an egalitarian environment in which farmers interact with peers and experts, with experts fulfilling a facilitating role, and farmers actively participating in goal and agenda setting. Meetings take place over a period of time, typically 1-3 years, and create knowledge by participatory learning methods, such as group or one-on-one meetings, training sessions and (experimental) demonstrations (Black 2000). The intended outcomes from PEPs include practice adoption, enhanced social learning, increased resilience to challenges and uncertainties, and improved farmer management skills and decision-making abilities (Cristóvão, Koutsouris and Kügler 2012). Overall, PEPs aim for cultural embeddedness of the key learnings via building cultural capital, i.e. the ideas stimulated in the PEP become embedded within the culture of farming and thus when the programme ends, farmers will continue incorporating the learnings into their farm management (Burton and Paragahawewa 2011). The identified aims will be discussed further in the Methods section, in which the evaluation framework is explained.

1.2 PEP evaluation

The majority of PEP evaluations have been conducted in developing countries (Knook et al. 2018; Van den Berg 2004), which might be due to the fact that the majority of PEPs are implemented in the developing world (Anderson and Feder 2004). The majority of the

evaluation literature to date is dominated by quantitative evaluations in which economic performance indicators are used to measure value for money, using indicators such as 'financial performance' and 'productivity' (Knook et al., 2018). Most studies show a positive return to programme participation in terms of an increase in financial performance or productivity, however, on closer inspection the calculation of returns is often questionable. Approximately 50 percent of peer reviewed evaluations do not properly account for self-selection bias, which occurs when participants have the opportunity to decide whether to participate in a study or not, and results in a sample bias (Knook et al., 2018). Randomised controlled trials are the favoured approach to address this bias, but these are limited due to contextual complexity, such as overcoming ethical restrictions when non-participants are disadvantaged because of exclusion from the treatment group(Duflo et al. 2007). Therefore, quasi-experimental approaches are often applied, such as propensity score matching (e.g. Läpple and Hennessy 2015). This method accounts for sample bias by matching participants from the control and treatment group on social, economic and biophysical characteristics (Läpple and Hennessy 2015; Stuart 2010).

Although PEPs are mostly evaluated using quantitative approaches, these may actually limit the questions studied (Munro 2014; Cartwright 2009). Using only quantitative evaluation approaches is criticised for overlooking other intended outcomes, such as enhanced social learning (Munro 2014; Cartwright 2009), and thus falling short of a holistic evaluation of a PEP (Knook et al., 2018; Murray, 2000). Prager & Creaney (2017) and Sewell et al. (2017) are two of few studies that go beyond adoption rates, by including a qualitative evaluation of levels of learning, knowledge and practice change, which are important indicators to provide insight into long-term behavioural change (Muro and Jeffrey 2008). There are few studies that apply both qualitative and quantitative methods. A recent example of Hill et al. (2017) applied a quasi-experimental and a 'naïve' approach, in which participants were asked to list their own sense of progress in the adoption of new practices. However, these studies do not include other aspects of PEPs, such as whether programme participation improves management skills, which are addressed by Kraaijvanger et al. (2016). Overall, these studies show that holistic evaluations are likely to require a mix of qualitative and quantitative methods, as well as a set of indicators in addition to practice adoption, to provide greater depth of understanding (Davies, Nutley and Smith 2000; Montuschi 2014).

2. Methods

2.1 Case study

To evaluate the potential contribution of a PEP to climate friendly farming we selected a PEP in Scotland focused on enhancing the uptake of GHG emission mitigation practices: Farming for a Better Climate (Scotland's Rural College 2020). This PEP was initiated in 2010 by the Scottish Government with the aim of contributing to the development of a 'low carbon society' (The Scottish Government 2010). The selected PEP targeted farm practices in five topic areas: using electricity and fuel efficiently, developing renewable energy (RE), locking carbon into the soil, making the best use of nutrients, and optimising livestock management. The practices were promoted as 'no-cost', suggesting that they could reduce emissions while maintaining (and in some circumstances increasing) farm profits. The programme was not part of the Scottish Rural Development Plan under the European Union's (EU) Common Agricultural Policy (CAP), but was a national policy outlined in the first Report on Proposals and Policies in 2010 (The Scottish Government 2010). The PEP was expected to increase the uptake of voluntary emission reduction measures by 50% amongst farmers (The Scottish Government 2013). At the time of evaluation, the PEP was the main Scottish policy tool to achieve on-farm GHG emissions reductions (The Scottish Government 2017). Although the PEP was not funded under the CAP, Scotland has similar market systems to other EU countries, which makes potential findings relevant for other EU and strictly regulated countries facing the implementation of agricultural climate change policy.

Focus farms were part of the PEP in order to provide knowledge exchange between researchers, extension agents and farmers. These farms shared and implemented new practices while functioning as a platform for discussion group meetings with peers, researchers and experts. Discussion group meetings were organised on the focus farms: four focus farms hosted discussion groups from 2010 to 2013, and nine focus farms operated from 2014 to 2017. Wider data collection relating to the potential contribution to emission reduction of the discussion group meetings was not a requirement of the programme. To identify the potential contribution to emission reductions of discussion group members, our evaluation focused on the farmers participating in the discussion group meetings. Participation in the discussion group meetings was on a voluntary basis and as a consequence the group composition changed through time, depending on the schedule and interest of the farmers. This meant some of the farmers only attended a few meetings, which was taken into account as a limitation of the evaluation. The topic, content, timing and location of the meetings were planned based on discussions between the focus farm, the farm advisor and farmers who were part of the discussion group.

Over the course of the programme at least 800 farmers attended the discussion group meetings. To provide some context for the scale of the PEP, in total there are 37,735 farmers in Scotland (Scottish Government 2018), including full-time and part-time farmers, of which approximately 30,000 are likely to be located in the targeted areas, meaning that circa 3% of the target farmers participated in the discussion groups. Although the PEP was the only policy focused on reducing on-farm GHG emissions specifically, some of the farmers in the target area were part of the Nitrate Vulnerable Zone (NVZ), designated areas requiring farmers to comply with a nutrient management plan (Scottish Government 2019), which might lead to different soil management practices outside the influence of the PEP. However, due to the lack of geospatial data, we were not able to account for this in the evaluation. Furthermore, due to the lack of baseline data collection, this was a 'retrofit' evaluation, i.e. only data collected after programme participation is used for evaluation given the lack of an initial set up of an evaluation framework.

2.2 Evaluation framework

We used the results from a previously conducted literature review of published PEP evaluation studies (Knook et al. 2018) as the basis for our evaluation framework. This review provided insight into the key characteristic aims of PEPs, and recommended these characteristic aims as the basis for an evaluation framework.. The characteristic aims of PEPs were identified as: i) *Practice adoption*; ii) *Social learning*, iii) *Resilience to challenges and uncertainties*; and iv) *Management skills and decision-making abilities,* and the resulting structure of the evaluation framework is illustrated in Figure 1.

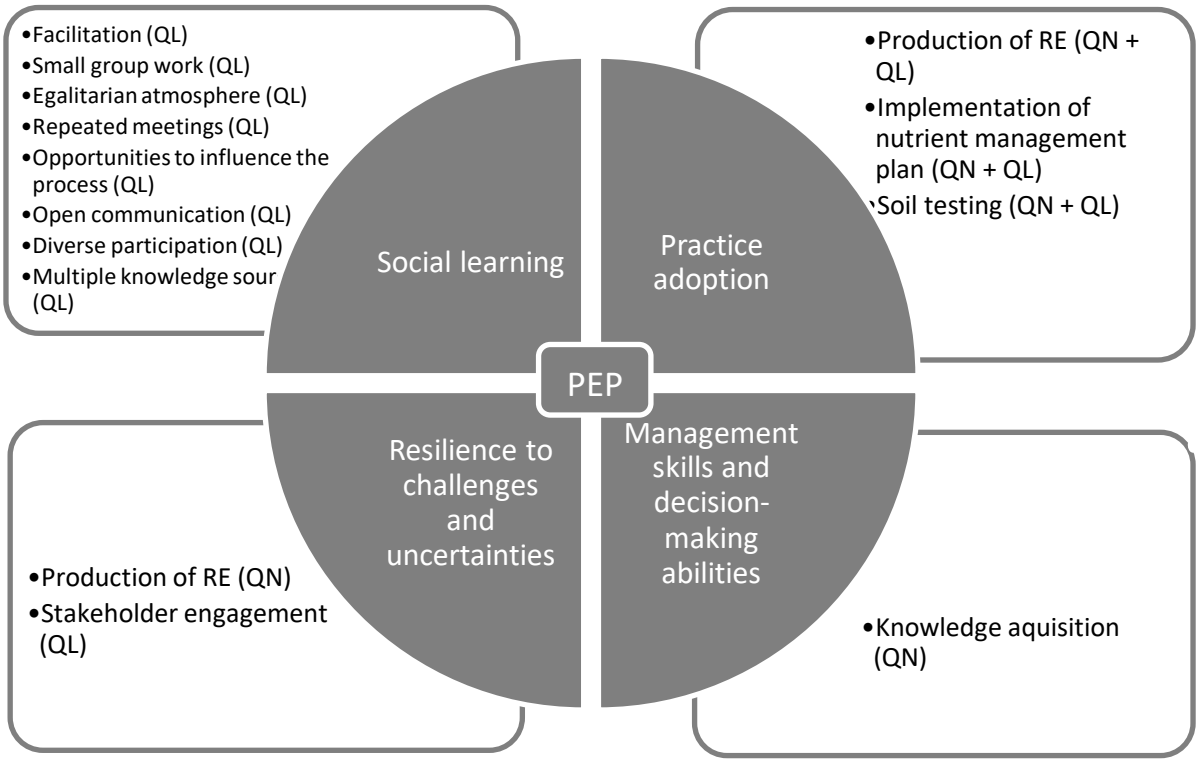

Figure 1: The evaluation framework. RE means renewable energy, QN refers to measuring the indicator by a quantitative approach. QL refers to measuring the indicator by a qualitative approach.

Social learning is seen as an essential component of successful participatory approaches (Muro and Jeffrey 2008; Prager and Creaney 2017). In the field of participatory natural resource management, social learning is generally defined as including communication and interaction of different actors within a participatory setting, which results in social outcomes, such as knowledge generation, acquisition of technical and social skills, and the development of trust and relationships. We based the selection of indicators on the compound model proposed by Muro & Jeffrey (2008), which suggested the following indicators: i) facilitation, which indicates the level of skills of the facilitator to lead a group and build trust, and the neutrality of the facilitators' role; ii) small group work, which refers to the possibility to learn in a small group setting by being helped by experts; iii) egalitarian atmosphere, which refers to the equality of researchers, extension agents and farmers in their process of interaction; iv) repeated meetings, which refers to a series of meetings being organised; v) opportunities to influence the process, which includes the possibility to influence the agenda; vi) open communication between actors, in which (on-farm) experiences are shared; vii) diverse participation of stakeholders, which refers to a number of stakeholders from different

backgrounds participating in the meetings; viii) multiple sources of knowledge, such as theoretical knowledge as well as practical demonstrations.

Practice adoption refers to the permanent integration of a new practice into the existing farming system. Measuring the rate of adoption was achieved by conducting a quantitative evaluation using performance indicators, which were selected based on: the key aims of the case study PEP, and the measurability amongst all survey respondents. The indicators selected were: renewable energy generation (renewable heat and electricity); nutrient management plan implementation; and soil testing.

Insight into the third aspect of a PEP, *Management skills and decision-making abilities*, also known as managerial capacity, was obtained by measuring the cognitive and intellectual skills of the farmer using a knowledge test (Rougoor et al. 1998). Although managerial capacity is influenced by more than intellectual skills, such as farmers' motivations, background, and experience, we were not able to capture this data in the quantitative survey. Hence, we decided to use a knowledge test as a proxy indicator for management skills as such tests have been widely applied in other studies (Feder, Murgai and Quizon 2004b; Khan, Ahmad and Walter-Echols 2005; Mancini, Van Bruggen and Jigginis 2007; Rejesus et al. 2012). The test consisted of six questions about 'using electricity and fuel efficiently' and 'locking carbon into the soil', which were both part of the five topic areas targeted by the PEP. The test indicated whether PEP farmers are more aware of mitigation measures compared to non-participating farmers.

Resilience is defined as the capacity of a system to cope with stress, overcome adversity, or adapt positively to change (Meuwissen 2018) in order to meet future food and development needs without depleting the earth's resources (Bennett et al. 2014). At the farm level, resilience can be measured by: robustness, which refers to the ability to maintain a similar level of outputs when faced with perturbations (Urruty, Tailliez-Lefebvre and Huyghe 2016); adaptability, which is the capacity of actors to adjust responses to influence resilience (Folke et al. 2010); and transformability, which is the capacity to respond to untenable environmental, economic or social structures by creating a fundamentally new system (Walker et al. 2004). We only included indicators for robustness and adaptability, because transformability was considered outside the scope of the PEP. The following proxy indicators were selected: i) implementation of RE, because securing a source of power for the future increases resilience (this indicator is also used to assess *Practice adoption*); and ii) including new stakeholders in management (advice) of the farm, because collaboration of farmers with peers, researchers, extension agents

and policy actors regarding climate change activities can increase robustness and adaptability by being exposed to new knowledge these actors bring.

2.3 Data collection and analysis

The quantitative effect of the programme was estimated using a quasi-experimental approach, while for the qualitative indicators observations and semi-structured interviews were conducted.

2.3.1 Quantitative approach

A 20-minute phone survey was conducted to collect data on the quantitative indicators (see Fig. 1) of *Practice adoption, Management skills and decision-making* and *Resilience* amongst the respondents. The survey (Appendix 1) was conducted targeting three groups, consisting of 340 farmers in total:

i) 2010-2013 PEP (n = 36): farmers who participated in the discussion groups of the programme in this period
ii) 2014 - 2017 PEP (n = 114): farmers who participated in the discussion groups of the programme in this period
iii) Control group (n = 190): farmers who did not participate in any of the PEP activities

We obtained the contact details for the treatment group from the recorded attendance list of meetings, while contact details for the control group were recruited via a stratified randomised sample from the Scottish Government national database of agricultural producers. The survey was conducted by a professional data collection team in December 2017 and January 2018.

To estimate the Average Treatment Effect (ATT) on the treatment group the data from the phone survey was analysed using a quasi-experimental approach, propensity score matching (Rubin 1974; Stuart 2010), to account for self-selection bias (Salhofer and Streicher 2005; Pufahl and Weiss 2008). Firstly, we estimated the propensity score of the respondents based on the covariates. A statistical summary of the matching characteristics before matching is provided in Appendix 2, Table 1. The matching characteristics were selected based on previous studies (e.g. Läpple and Hennessy 2015) and were known not to be directly linked to the outcome variables. The multivariate analysis (Appendix 2, Table 2) showed that the PEP and control group differ on: agricultural education; rented land; limited soil type; years of

experience; and presence of livestock on the farm. By matching the PEP and control group the differences between these groups were removed, which then accounted for potential adoption bias between the groups.

Secondly, the farmers from the treatment and control groups were matched based on their propensity score, by applying *k:1* nearest neighbour matching[1] (Stuart 2010). A caliper of 0.25, as suggested by Rosenbaum & Rubin (1985a), was implemented to avoid poor matches (Rosenbaum and Rubin 1985b).

Thirdly, the matching quality was checked to assure that the mean of all variables are statistically the same between the treatment and control group. We used numerical and graphical diagnostics to assess the quality of the matches, which was based on the covariate balance (Stuart 2010). In order to select the best model, which differed based on explanatory variables and model specification, we used the log-likelihood and Akaike information criterion values (Cameron and Trivedi 2005). Matching was considered successful because the significant differences between the covariates disappeared (Appendix 2, Table 3). Furthermore, the overall significance of the logit model should be rejected after matching (Caliendo and Kopeinig 2008), which is observed in our model: pre-matching the likelihood ratio chi-square was significant, whereas after matching joining significance of all models was rejected. Also, the pseudo-R^2 is supposed to be low, which is observed when we compare the pre-matching (Appendix 2, Table 2) with the after-matching (Appendix 2, Table 3).

Lastly, to compare both treatment groups with the control group after successful matching, two comparisons were made (Heckman, Tobias and Vytlacil 2001):

Comparison I: 2010 – 2013 PEP farmers and control farmers
Comparison II: 2014 – 2017 PEP farmers and control farmers

Subsequently, the data was analysed by conducting a linear regression based on the outcomes of the treatment and control group and quantifying the ATT.

Comparison I: ATT_1 (Eq. 1)
Comparison II: ATT_2 (Eq. 2)

$$ATT_1 = E\,[Y(1)|D = 1] - E\,[Y(0)|D = 1] \quad (1)$$

[1] While applying nearest neighbour matching, our results are robust to other matching techniques, such as kernel matching.

296 ATT_1 is the average treatment effect on the farmers who participated in the PEP from 2010 until
297 2013, where $D = 1$ indicates PEP participation and $D = 0$ indicates the farmer did not participate
298 at all. Y refers to each observed farmer in the participation (1) or non-participation (0) state and
299 E is the expected value.

$$ATT_2 = E\,[Y(2)|D = 2] - E\,[Y(0)|D = 2] \quad (2)$$

300 ATT_2 is the average treatment effect on the farmers who participated in the PEP from 2014 until
301 2017, where $D = 2$ indicates PEP participation and $D = 0$ indicates the farmer did not participate
302 at all.

303 Due to participation in the PEP, we expected a positive ATT on the performance indicators
304 *production of RE, implementation of nutrient management plan, soil testing* and *knowledge*
305 *acquisition* for the PEP farmers in Comparisons I and II (described in Appendix 2, Table 1).

306 2.3.2 Qualitative approach

307 To gain insight into *Social learning, Resilience* and farmers' perception of *Practice adoption,*
308 qualitative data was collected by conducting semi-structured interviews (Appendix 4),
309 analysing meeting notes, and observing discussion group meetings. We selected the interview
310 participants based on: i) participation in the PEP; ii) interest in participating in further research
311 after participation in the phone survey; iii) meeting attendance: only respondents who had
312 attended more than two meetings were invited; and iv) the geographical location, to allow
313 inclusion of respondents from different farm discussion groups. An overview of the 20
314 respondents is provided in Appendix 3. Interview themes included the background of the
315 farmer and the farm; the farmers' views on participation in the PEP; the views on the facilitator,
316 experts and peer interaction; and the practice and behavioural changes made due to
317 participation in the PEP.

318 All interviews were recorded and fully transcribed. Subsequently, we conducted open coding
319 on the first three interview transcripts to ensure important aspects of the data were not missed
320 and to ensure the codes based on the indicators of the framework covered the remarks made by
321 the interviewees (Fig.1). Furthermore, to ensure the suitability of the framework we allowed
322 for data triangulation by adding the findings from the meeting observations and notes. After
323 confirming the suitability of the coding framework, we started deductive coding by going

through all transcripts and placing interviewees' remarks under each of the indicators of the framework. Remarks were categorised as 'supportive' if an interviewee was positive about an indicator or 'unsupportive' if the interviewee had negative remarks on an indicator.

3. Findings

The findings for each of the indicators is summarised in Table 1 and elaborated on in the subsections below.

PEP elements	Indicators	Findings		Overall assessment
		Findings 2010-2013 group	Findings 2014-2017 group	
Practice Adoption	Production of renewable electricity	0.47** (0.056)	0.27*** (0.025)	Positive, practice adoption is higher under PEP participants.
	Production of renewable heat	0.31** (0.046)	0.18 (0.023)	
	Implementation of nutrient management plan	0.58 (0.057)	0.84*** (0.03)	
	Soil testing	0.97* (0.037)	0.99*** (0.022)	
Social learning	Facilitation	n/a	+/-	Mixed, repetitive meetings are organised, but farmers only attend a small number of these meetings. This leads to lack of egalitarian atmosphere and open communication.
	Small group work	n/a	-	
	Egalitarian atmosphere	n/a	-	
	Repeated meetings	n/a	+	
	Opportunities to influence the process	n/a	-	
	Open communication	n/a	-	
	Diverse participation	n/a	+	
	Multiple knowledge sources	n/a	+	
Resilience to challenges and uncertainties	Production of renewable electricity	0.47** (0.056)	0.27*** (0.025)	Mixed, PEP farmers show higher generation of RE compared to control farmers, but the interviews show this is not attributable to PEP participation.
	Production of renewable heat	0.31** (0.046)	0.18 (0.023)	
	Stakeholder engagement	n/a	-	
Management skills and decision-making abilities	Knowledge acquisition	4.78 (0.12)	4.83** (0.07)	Mixed, farmers who recently participated in the PEP show a higher level of knowledge, whereas farmers participated >4 years ago do not.

Table 1: Estimation of average treatment effect on the treated (for quantitative indicators). *,**,* Significant at 0.1%, 1%, 5% level, respectively. The evaluation of the qualitative indicators is depicted by using '-' for a negative effect, '+' for a positive effect and +/- if the evaluation is not positive or negative. n/a refers to 'not applicable', for these indicators no data is available.**

3.1 Participation

Farmers were included in the 'PEP group' based on attendance records showing that they had participated in the PEP. However, a number of members of the PEP group did not recall

participating in the programme: 9 respondents indicated having attended one meeting; 36 indicated having attended 2-3 meetings; 30 indicated having attended more than 3 meetings; and 75 respondents indicated not having attended any meeting. The significance of the awareness of participation is discussed below.

3.2 Practice adoption

The ATTs for *Practice adoption* mostly indicate positive returns. However, the semi-structured interviews show only three respondents mentioned the adoption of a practice specifically due to participation in the PEP and one respondent indicated that attending the meetings offered an opportunity to explore and reflect on current management practices, leading to a potential change:

'The likes of the cover crops ideas, I am coming around to that, but I don't know if that's specifically because of the meeting, it's maybe more the people I met at the meeting and where I discussed with what they were doing and checking whether I could give them a ring about that.' – Respondent 3

However, respondent 18 could not attribute a specific change to participation in the PEP:

'I wouldn't say so that it only comes from the meetings. I think that's almost like a change in, just all the different media that you get different things from.' – Respondent 18

Secondly, respondents discussed the implementation of nutrient management plans during the interviews. Some farmers implement a nutrient plan because of the Nitrate Vulnerable Zone, which indicates a potential attribution problem, i.e. the farmers implemented nutrient management plans because they are obliged to do so, and not because of participation in the PEP. As discussed in the Methods section, due to the lack of geospatial data we could not correct for this in the quantitative analysis.

3.3 Social learning

Overall, respondents indicated that they considered the facilitators to be good organisers, well-prepared, and good at communicating. However, due to discussion groups being facilitated by different facilitators, there was variation in respondents' views. Respondents from two different discussion groups both mention the influence the facilitator had on the group, which in one case has had a positive and in the other case a negative effect:

'Facilitator x is pretty good, yes. He has been around the block a bit, he knows quite well what's going on and what we've been doing. He also tells people to shut up and go on with it, because otherwise we get very side tracked and we end up waffling on about things that aren't really relevant. But the facilitator is actually very important.' – Respondent 2

'I didn't think it was maybe quite, I don't know if firm enough is the right word, but there should have been more leadership I think. But that's hard if that's the personalities that are involved.' – Respondent 3

Respondents indicated that the facilitators organised sufficient opportunities to discuss with peers and experts during the meetings, by planning small group sessions for example. Although meetings were attended by a diverse group of participants and theoretical sessions as well as practical demonstrations were provided, respondents did not experience an egalitarian atmosphere. Respondents mentioned the lack of understanding from experts during the meetings:

'Well I manage to say things, but they all seem to think I'm crazy about what I do. It's not the normal idea.'- Respondent 1

'The theory and practice is just too different. Until we get somebody there who understands all that and puts it in the practical sense.'- Respondent 15

The meeting notes show eight to twelve meetings were organised for each of the focus farms. Approximately half of the interviewed farmers attended more than three meetings. Other farmers indicated that they only attended two to three meetings, based on their interest in the topic of the meeting. Respondents' views on influencing agenda-setting were mixed, with approximately half of the farmers experiencing the opportunity to influence agenda topics:

'We actually hosted one [meeting] here, that was one of the climate things. We took people out to the hydro. It was one of the meetings connected to [focus farm x]. That would be one of the inputs that I brought in.'- Respondent 12

The other half had the impression the agenda for the meetings was already set by the organising institution:

'I would say it was already a predetermined agenda. And they have their ideas and that's it. And they are like 'oh you can discuss it', but they didn't pay any attention.'- Respondent 1

'I think the agenda was already set for the meetings. I never had much input into the meetings.' – Respondent 18

Overall, the participating farmers responded positively to the frequency of meetings, the diversity of participation, the presence of small group sessions and the multiple sources of knowledge. There were mixed responses on agenda-setting and the facilitation of meetings, possibly due to different facilitators. Respondents generally expressed negative views about the egalitarian atmosphere and the openness of communication.

3.4 Management skills and resilience

The analysis shows that PEP participants produced significantly more RE compared to the control farmers (Table 1). However, interviewees did not attribute this change to PEP participation, but stated that they decided to implement RE independently of the PEP, because of the financial benefit to the farm:

'It was most about diversifying, just to get another income. Because we needed another stream of income for profitability, it's just another thing to bring into the pot.' – Respondent 4

'I thought it was an expensive fuel bill and I thought let's try to decrease that a wee bit.' – Respondent 7

The second indicator, stakeholder engagement, shows that some respondents obtained contacts due to the meetings:

'The company I'm now buying my feed for the cows, he left his business card here when I wasn't at home that day. Then I ended up speaking with him at one of these climate change event things. From that I ended up buying feed from them. That was due to the climate change meeting. So it was worthwhile like that.' – Respondent 16

However, there was no indication that PEP farmers included new stakeholders, such as experts or advisors, in running their farms.

A significant effect for the knowledge test was only found in Comparison II, whereas participants in Group I, who participated in the PEP longer time ago (2010 to 2013), do not show a significant effect. The implication of this result is discussed below.

4. Discussion

The purpose of this study was to: i) evaluate the effectiveness of PEPs in enhancing the uptake of climate friendly farming practices; and ii) contribute to the development of an effective evaluation framework for such participatory programmes. The discussion below explores the main implications of the findings in terms of the contribution of the PEP to climate friendly farming, and then draws out the main theoretical and practical implications.

4.1 PEP contribution to climate sustainable farming

The main aim of the PEP studied in this paper was to contribute towards climate friendly farming. The evaluation in the current paper shows that PEP participants had a higher rate of adoption of climate change mitigation practices, i.e. production of renewable energy, implementation of a nutrient management plan and soil testing. The positive finding of practice adoption after PEP participation is supported by other studies conducted in developed countries (Läpple et al. 2013; Läpple and Hennessy 2015; Goodhue, Klonsky and Mohapatra 2010; Tamini 2011). The semi-structured interviews however, show that not all respondents attribute the changes to the PEP. This is divergent to findings reported by Hill et al. (2017), in which farmers' self-assessment on the effect of the 'Farmer Connect' programme (a programme delivering knowledge transfer and advice to farmers in Wales) shows a straightforward positive effect. This divergence might be caused by the set-up of the Farmer Connect programme: participants were required to meet a share of the cost, leading to an optimism bias (Sharot 2011) in which participants possibly overestimated programme benefits. Farmers are willing to pay for extension services if relevant to their needs (Prager et al. 2016; Ozor, Garforth and Madukwe 2013), but research has not yet focused on the effect co-funding in PEPs might have on farmer motivation to take up new practices. This is an area to explore in the design of future PEPs.

Another explanation of the more positive outcome of the quantitative analysis compared to the qualitative analysis, is that farmers might not attribute the adoption of practices to being concerned about climate change. A paper by Tripathi & Mishra (2017) shows that although farmers implement climate change mitigation practices, such as changing cropping patterns and agroforestry, they do not attribute that change to a motivation to contribute to climate change mitigation. Instead, they indicate that practice change is motivated by having to deal with a changing socio-economic situation, such as changing market prices. We hypothesise that something similar might be happening amongst the Scottish farmers. The climate change PEP stimulated the uptake of practices that were 'win-win': both climate and cost effective.

Hence, farmers might have adapted climate change mitigation practices, but do not recognise them as such, because they have implemented these practices to make the farm more cost-effective. Thus, they do not link their practice adoption to a climate focused PEP. We find that in the qualitative interviews most farmers mentioned financial reasons as the main motivation to take up climate change practices, which supports our hypothesis of farmers not recognising climate change mitigation measures as such.

However, we question the successful sustained adoption of such practices when climate change mitigation measures are framed as cost-effective. Finding strong financial motivations to adopt suggests that the programme achieved limited 'cultural embeddedness', i.e. where the focus for practice change is on non-economic motivations such as wider public goods and doing the 'right thing'. A common criticism of financial incentives for promoting the uptake of environmental practices is that they do not achieve long lasting change, as they fail to redefine a 'good farmer' identity (Burton and Paragahawewa 2011; de Snoo et al. 2013; Lokhorst et al. 2011; Van Herzele et al. 2013). Historically, the dominant 'good farmer' identity has consisted of maximising on-farm production, with 'good farming' practices being 'productivist' practices (Haggerty, Campbell and Morris 2009), such as good crop appearance and financial viability. Climate change mitigation practices might clash with such historic 'good farming' beliefs: farmers are interested in uptake of farm measures that demonstrate economic success, than less tangible signs of 'good environmental farming' (Burton, Kuczera and Schwarz 2008). Therefore, farmers might be less likely to adopt new, e.g. climate sustainable, practices if this does not align with the beliefs of 'good farming' (Burton 2004; Inman et al. 2018; McGuire, Morton and Cast 2013). Hence, we question whether PEP participants are likely to take up climate change mitigation practices after programme participation if they are motivated to do so because of financial reasons. Future programmes might benefit from reimagining the 'good farmer' identity to gain embedded practice change by focusing less on financial motivations and more on social norms (Burton 2004; Flemsæter, Bjørkhaug and Brobakk 2018).

4.2 PEP design

In our study, *Practice adoption* and *Social learning* might have been hampered by the lack of repeated farmer attendance at meetings. The majority of the farmers did not attend more than 2-3 meetings, whereas the literature suggests that a stable discussion group over extended periods, with personal interaction between farmers with experts or peers, is necessary for building trust and achieving behavioural change (Sutherland et al. 2013; Mills et al. 2008; Muro

and Jeffrey 2008; Muro and Jeffrey 2012). Encouraging farmers to attend multiple meetings might improve *Social learning* and can be enhanced by explicitly showing the 'benefits' a programme brings to farmers (Kraaijvanger et al. 2016; Mapfumo et al. 2013). Furthermore, allowing farmers to influence the choice of practices promoted by a PEP is also likely to motivate participation. Additionally, our findings are supported by the recommendation in Islam et al. (2011): the selection of group leaders and facilitators should not only be based on technological competency, but also on personality traits, such as innovativeness, sincerity and trustworthiness, and could play an important role in successful programme design and the sustainability of the groups. Furthermore, similar to Vrain and Lovett (2016) and Cristóvão et al. (2012), our findings show the importance of increasing understanding of the influence of different facilitators on establishing a stable discussion group. Therefore, further evaluation should explore the influence of training facilitators, researchers and extension experts involved in the programme.

Lastly, results from the survey and interviews suggested that some of the PEP farmers have a poor recollection of attending the meetings, or do not associate attending meetings with the PEP when it was named. The observation of low recognition of the PEP name despite positive effects shown by participation questions whether programme recognition matters for the success of the PEP and for future policy aims associated with such PEPs. Furthermore, we have observed that there is a large number of farmers who only attended a few meetings. These questions are worth exploring in further research, particularly concerning the issues of focusing on project attribution and programme attendance versus project impact.

4.3 Methods and data for evaluation

4.3.1 Additions to the evaluation framework

By stimulating *Practice adoption, Social learning, Resilience,* and *Management skills,* PEPs generally aim to contribute to the cultural embeddedness of the practices being promoted. However, measuring the effect of PEPs based on these four indicators does not provide insight into the cultural embeddedness of ideas stimulated by a PEP. Therefore, for future evaluation frameworks we suggest the development of indicators from institutional theory which focuses on the processes involved in establishing long term change (Smets, Morris and Greenwood 2012; e.g. Gray, Purdy and Ansari 2015). Institutional theory studies change by looking at institutional logics, which are 'the socially constructed, historical patterns of cultural symbols and material practices, including assumptions, values, and beliefs, by which individuals and

organisations provide meaning to their daily activity, organise time and space, and reproduce their lives and experiences' (Thornton, Ocasio and Lounsbury 2012 p. 2). The culture of farming consists of multiple logics, which are thus each constituted by a set of practices, beliefs and values. Institutional theory states that to establish change, we need to focus on changing these logics by shifting not only practices, but also beliefs and values. Hence, when we conduct an evaluation and we want to measure sustained change, only studying practice change does not provide sufficient insight. Therefore, the change in beliefs and values underlying those practices should be studied as well. Studying these values, beliefs and practices can be done by interviewing farmers about their day-to-day activities and their motivations behind these activities, as well as by visiting the farm and understanding farm systems. By including farmers before and after the programme may provide insight in not only change due to the programme, but might also help in identifying the mechanisms that are responsible for this change.

Another point to take into account in future PEP evaluation is the assessment of goals set by the participants themselves. In the current evaluation, no baseline data was available, which led us to only evaluate the indicators set by the PEP organisers/funders. However, in a truly participatory programme participants are able to set their own programme goals. Hence,future evaluation data should be collected on the goals formulated by the funders and/or programme designers as well as by the participants, to account for the participatory process in which the participants' goals cannot be rigidly defined at the start of the PEP (Dart 2000). Following the baseline data collection, a mid-term evaluation should be conducted to reflect and analyse whether the PEP is achieving its objectives, both from a funders' and participants' perspective. At the end of the PEP an ex-post evaluation should conducted to gain insight into the goals set out by funders, organisers, and participants at the initiation of the programme (Faure et al. 2012). Based on the evaluation learnings, the design of future programmes can be optimised. Ideally, this leads to funders' goals increasingly aligning with participants' goals.

4.3.2 Limitations of the evaluation methods

The quasi-experimental method used in this study has a limitation in terms of correctly measuring the magnitude of change. For example, in the propensity score matching unobservable characteristics cannot be taken into account, which McKenzie et al. (2010) suggest can lead to a 20% estimation bias. For the present study, this could mean that there is no significant positive effect from the PEP in reality. Secondly, the knowledge test used to evaluate *Management skills* only shows a significant result for farmers who recently

552 participated in the PEP. The lack of a significant difference in the 2010-2013 group may be
553 caused by the complexity of the knowledge disseminated by the PEP, or the effect may be too
554 small to be detected by the econometric analysis, which has previously been observed in a
555 study by Feder et al. (2004a). Thirdly, the qualitative interviews were only conducted with
556 farmers who were members of the PEP group, and we were not able to interview farmers who
557 had not participated in the PEP. Fourthly, an inherent difficulty of evaluating PEPs like these
558 is controlling for different information channels. Farmers might receive their information via
559 multiple pathways, such as other discussion groups, field days and the internet, which is
560 difficult to control for when only having access to cross-sectional data.

561 To improve the quality of the econometric analysis and increase the accuracy of measurement,
562 we highlight the importance of baseline data collection for future evaluation (Feder et al.,
563 2004a). To gain insight into the motivations for making (or not making) changes on farms, we
564 suggest that future research should also aim to conduct qualitative interviews with farmers not
565 involved in a programme. To account for different information channels, longitudinal data
566 collection is required, which, via for example a randomised controlled trial or the differences-
567 in-differences approach, accounts for unobservable characteristics.

568 ## 5. Conclusion

569 This evaluation contributes to the limited published information on the success of climate
570 change PEPs. The divergence between the findings from the quantitative and qualitative
571 method shows that the use of mixed methods is highly important to gain understanding in the
572 overall functioning of PEPs. Furthermore, the lack of proof for sustained change leads us to
573 suggest that programmes such as the PEP evaluated in this study need to be part of a broader
574 suite of measures, e.g. together with regulation, subsidies, and customer pressure, as they are
575 currently not sufficient to create a climate sustainable farming culture on their own. Further
576 research into other PEPs would be useful, e.g. how to change farmer beliefs and values to
577 establish long-term change. To gain insight into this long term change, quantitative and
578 qualitative baseline data, in combination with continuous observations, might prove useful to
579 collect new insights. This would also allow for increased insight into the processes that lead to
580 change due to participation in extension programmes.

581

582 **References**

583 Anderson, J.R., and G. Feder. 2004. “Good intentions extension : Agricultural and hard
584 realities.” *The World Bank Research Observer* 19(1):41–60. Available at:
585 http://wbro.oxfordjournals.org/content/19/1/41.abstract.

586 Bennett, E., S. Carpenter, L. Gordon, N. Ramankutty, P. Balvanera, B. Campbell, W. Cramer,
587 J. Foley, C. Folke, L. Karlberg, J. Liu, H. Lotze-Campen, N. Mueller, G. Peterson, S.
588 Polasky, J. Rockström, R. Scholes, and M. Spierenburg. 2014. “Toward a More
589 Resilient Agriculture.” *Solutions* 5(5):65–75.

590 Van den Berg, H. 2004. “IPM farmer field schools: A synthesis of 25 impact evaluations.”

591 Black, A. 2000. “Extension theory and practice: a review.” *Australian Journal of*
592 *Experimental Agriculture* 40:493–502. Available at:
593 http://www.publish.csiro.au/?paper=EA97144.

594 Braun, A., and D. Duveskog. 2011. “The farmer field school approach – history , global
595 assessment and success stories.”

596 Burton, R.J.F. 2004. “Seeing through the ‘good farmer’s’ eyes: Towards developing an
597 understanding of the social symbolic value of ‘productivist’ behaviour.” *Sociologia*
598 *Ruralis* 44(2):195–215.

599 Burton, R.J.F., C. Kuczera, and G. Schwarz. 2008. “Exploring farmers’ cultural resistance to
600 voluntary agri-environmental schemes.” *Sociologia Ruralis* 48(1):16–37.

601 Burton, R.J.F., and U.H. Paragahawewa. 2011. “Creating culturally sustainable agri-
602 environmental schemes.” *Journal of Rural Studies* 27(1):95–104. Available at:
603 http://dx.doi.org/10.1016/j.jrurstud.2010.11.001.

604 Caliendo, M., and S. Kopeinig. 2008. “Some practical guidance for the implementation of
605 propensity score matching.” *Journal of Economic Surveys* 22(1):31–72. Available at:
606 http://onlinelibrary.wiley.com/store/10.1111/j.1467-6419.2007.00527.x/asset/j.1467-
607 6419.2007.00527.x.pdf?v=1&t=jb4dgxam&s=3873467ab7581441ca0c71658d6348f937
608 286d99.

609 Cameron, A., and P. Trivedi. 2005. *Microeconometrics - methods and applications*. New
610 York: Cambridge University Press.

611 Cartwright, N. 2009. “Evidence-based policy: What’s to be done about relevance?”
612 *Philosophical Studies* 143(1):127–136.

613 Cristóvão, A., A. Koutsouris, and M. Kügler. 2012. “Extension systems and change
614 facilitation for agricultural and rural development.” In I. Darnhofer, D. Gibbon, and B.
615 Dedieu, eds. *Farming Systems Research into the 21st Century: The New Dynamic*.
616 Dordrecht: Springer, pp. 201–227.

617 Dart, J.J. 2000. *Stories for change: a new model of evaluation for agricultural extension*
618 *projects in Australia*. The University of Melbourne.

619 Davies, H., S. Nutley, and P. Smith. 2000. *What works?: Introducing evidence-based policy*
620 *and practice in public services*. Bristol University Press. Available at:
621 http://dx.doi.org/10.1332/policypress/9781861341914.003.0001.

622 Davis, K., E. Nkonya, E. Kato, D.A. Mekonnen, M. Odendo, R. Miiro, and J. Nkuba. 2012.
623 “Impact of farmer field schools on agricultural productivity and poverty in East Africa.”
624 *World Development* 40(2):402–413. Available at:
625 http://dx.doi.org/10.1016/j.worlddev.2011.05.019.

626 Duflo, E., R. Glennerster, M. Kremer, and A. Latif Jameel. 2007. “Using randomization in
627 development economics research: a toolkit.” No. 333,

628 European Commission. 2015. “Unit E.4 (2015): Establishing and implementing the
629 Evaluation Plan of 2014-2020 RDPs.”

630 European Commission. 2010. “Working paper on approaches for assessing the impacts of the
631 Rural Development Programmes in the context of multiple intervening factors.”

632 Faure, G., Y. Desjeux, and P. Gasselin. 2012. “New challenges in agricultural advisory
633 services from a research perspective: A literature review, synthesis and research
634 agenda.” *The Journal of Agricultural Education and Extension* 18(5):461–492.
635 Available at: http://www.tandfonline.com/doi/abs/10.1080/1389224X.2012.707063.

636 Feder, G., R. Murgai, and J.B. Quizon. 2004a. “Sending farmers back to school: The impact
637 of farmer field schools in Indonesia.” *Review of Agricultural Economics* 26(1):45–62.

638 Feder, G., R. Murgai, and J.B. Quizon. 2004b. “The acquisition and diffusion of knowledge:
639 The case of pest management training in farmer field schools, Indonesia.” *Journal of*

Agricultural Economics 55(2):221–243.

Feder, G., A. Willett, and W. Zijp. 1999. "Agricultural Extension: generic challenges and some ingredients for solutions." No. 2129,

Flemsæter, F., H. Bjørkhaug, and J. Brobakk. 2018. "Farmers as climate citizens." *Journal of Environmental Planning and Management* 61(12):2050–2066. Available at: http://dx.doi.org/10.1080/09640568.2017.1381075.

Folke, C., S.R. Carpenter, B. Walker, M. Scheffer, T. Chapin, and J. Rockström. 2010. "Resilience thinking: Integrating resilience, adaptability and transformability." *Ecology and Society* 15(4).

Goodhue, R.E., K. Klonsky, and S. Mohapatra. 2010. "Can an education program be a substitute for a regulatory program that bans pesticides? Evidence from a panel selection model." *American Journal of Agricultural Economics* 92(4):956–971.

Gray, B., J.M. Purdy, and S. Ansari. 2015. "From interactions to institutions: Microprocesses of framing and mechanisms for the structuring of institutional fields." *Academy of Management Review* 40(1):115–143.

Haggerty, J., H. Campbell, and C. Morris. 2009. "Keeping the stress off the sheep? Agricultural intensification, neoliberalism, and 'good' farming in New Zealand." *Geoforum* 40(5):767–777. Available at: http://dx.doi.org/10.1016/j.geoforum.2008.12.003.

Heckman, J.J., J.L. Tobias, and E.J. Vytlacil. 2001. "Four parameters of interest in the evaluation of social programs." *Southern Economic Journal* 68(2):210–223. Available at: http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=5449543&site=ehost-live.

Van Herzele, A., A. Gobin, P. Van Gossum, L. Acosta, T. Waas, N. Dendoncker, and B. Henry de Frahan. 2013. "Effort for money? Farmers' rationale for participation in agri-environment measures with different implementation complexity." *Journal of Environmental Management* 131:110–120. Available at: http://dx.doi.org/10.1016/j.jenvman.2013.09.030.

669 Hill, B., D. Bradley, and E. Williams. 2017. “Evaluation of knowledge transfer; conceptual
670 and practical problems of impact assessment of Farming Connect in Wales.” *Journal of*
671 *Rural Studies* 49:41–49. Available at: http://dx.doi.org/10.1016/j.jrurstud.2016.11.003.

672 Inman, A., M. Winter, R. Wheeler, E. Vrain, A. Lovett, A. Collins, I. Jones, P. Johnes, and
673 W. Cleasby. 2018. “An exploration of individual, social and material factors influencing
674 water pollution mitigation behaviours within the farming community.” *Land Use Policy*
675 70(September 2017):16–26. Available at:
676 https://doi.org/10.1016/j.landusepol.2017.09.042.

677 IPCC. 2014. *Climate Change 2014: Mitigation of Climate Change*. Available at:
678 http://www.ipcc.ch/report/ar5/wg3/.

679 Jones, K., L.L. Glenna, and E. Weltzien. 2014. “Assessing participatory processes and
680 outcomes in agricultural research for development from participants’ perspectives.”
681 *Journal of Rural Studies* 35:91–100. Available at:
682 http://dx.doi.org/10.1016/j.jrurstud.2014.04.010.

683 Khan, M.A., I. Ahmad, and G. Walter-Echols. 2005. “Impact of an FFS-based IPM approach
684 on farmer capacity, production practices and income: evidence from Pakistan.” In P. A.
685 C. Ooi, S. Praneetvatakul, H. Waibel, and G. Walter-Echols, eds. *The Impact of the*
686 *FAO-EU IPM Programme for Cotton in Asia*. Hannover: the Pesticide Policy Project,
687 pp. 45–60.

688 Klerkx, L., F. Landini, and H. Santoyo-Cortés. 2016. “Agricultural extension in Latin
689 America: current dynamics of pluralistic advisory systems in heterogeneous contexts.”
690 *The Journal of Agricultural Education and Extension* 22(5):389–397. Available at:
691 https://www.tandfonline.com/doi/full/10.1080/1389224X.2016.1227044.

692 Knook, J., V. Eory, M. Brander, and D. Moran. 2018. “Evaluation of farmer participatory
693 extension programmes.” *Journal of Agricultural Education and Extension* 24(4):309–
694 325. Available at: https://doi.org/10.1080/1389224X.2018.1466717.

695 Kraaijvanger, R., T. Veldkamp, and C. Almekinders. 2016. “Considering change: Evaluating
696 four years of participatory experimentation with farmers in Tigray (Ethiopia)
697 highlighting both functional and human-social aspects.” *Agricultural Systems* 147:38–
698 50. Available at: http://dx.doi.org/10.1016/j.agsy.2016.05.001.

699 Läpple, D., and T. Hennessy. 2015. “Assessing the impact of financial incentives in extension
700 programmes evidence from Ireland.” *Journal of Agricultural Economics* 66(3):781–795.

701 Läpple, D., T. Hennessy, and C. Newman. 2013. “Quantifying the economic return to
702 participatory extension programmes in Ireland: An endogenous switching regression
703 analysis.” *Journal of Agricultural Economics* 64(2):467–482.

704 Lokhorst, A.M., H. Staats, J. Van Dijk, E. Van Dijk, and G. De Snoo. 2011. “What’s in it for
705 Me? Motivational differences between farmers’ subsidised and non-subsidised
706 conservation practices.” *Applied Psychology* 60(3):337–353.

707 Mancini, F., A.H.C. Van Bruggen, and J.L.S. Jigginis. 2007. “Evaluating cotton integrated
708 pest management (IPM) farmer field school outcomes using the sustainable livelihoods
709 approach in India.” *Experimental Agriculture* 43(01):97. Available at:
710 http://www.journals.cambridge.org/abstract_S001447970600425X.

711 Mapfumo, P., S. Adjei-Nsiah, F. Mtambanengwe, R. Chikowo, and K.E. Giller. 2013.
712 “Participatory action research (PAR) as an entry point for supporting climate change
713 adaptation by smallholder farmers in Africa.” *Environmental Development* 5(1):6–22.
714 Available at: http://dx.doi.org/10.1016/j.envdev.2012.11.001.

715 McGuire, J., L.W. Morton, and A.D. Cast. 2013. “Reconstructing the good farmer identity:
716 Shifts in farmer identities and farm management practices to improve water quality.”
717 *Agriculture and Human Values* 30(1):57–69.

718 McKenzie, D., J. Gibson, and S. Stillman. 2010. “How important is selection? Measures of
719 the income gains from migration.” *Journal of the European Economic Association*
720 8:913–945. Available at: http://doi.wiley.com/10.1111/j.1542-
721 4774.2010.tb00544.x%5Cnpapers3://publication/doi/10.1111/j.1542-
722 4774.2010.tb00544.x.

723 Meuwissen, M. 2018. “Report on resilience framework for EU agriculture.”

724 Millar, J. 2011. “The role of extension for improving natural resource management: The
725 Australian experience.” In J. Jennings, R. Packham, and D. Woodside, eds. *Shaping*
726 *Change: Natural Resource Management, Agriculture and the Role of Extension*.
727 Australia: Australasia-Pacific Extension Network (APEN), pp. 102–110.

728 Mills, J., J. Ingram, M. Reed, C. Short, D. Gibbon, and J. Dwyer. 2008. “Evaluation of key
729 factors that lead to successful agri-environmental co-operative schemes.” Available at:
730 http://www.academia.edu/2550148/Evaluation_of_key_factors_that_lead_to_successful
731 _agri-environmental_co-operative_schemes.

732 Montuschi, E. 2014. “Scientific Objectivity.” In *Philosophy of social science: a new*
733 *introduction*. Oxford: Oxford University Press, pp. 123–144.

734 Munro, E. 2014. “Evidence-Based Policy.” In N. Cartwright and E. Montuschi, eds.
735 *Philosophy of social science: a new introduction*. Oxford: Oxford University Press, pp.
736 48–67.

737 Muro, M., and P. Jeffrey. 2008. “A critical review of the theory and application of social
738 learning in participatory natural resource management processes.” *Journal of*
739 *Environmental Planning and Management* 51(3):325–344.

740 Muro, M., and P. Jeffrey. 2012. “Time to talk? How the structure of dialog processes shapes
741 stakeholder learning in participatory water resources management.” *Ecology and Society*
742 17(1).

743 Murray, P. 2000. “Evaluating participatory extension programs: Challenges and problems.”
744 *Australian Journal of Experimental Agriculture* 40(4):519–526.

745 Olander, L.P., E. Wollenberg, F.N. Tubiello, and M. Herold. 2014. “Synthesis and review:
746 Advancing agricultural greenhouse gas quantification.” *Environmental Research Letters*
747 9(7).

748 Ozor, N., C. Garforth, and M.C. Madukwe. 2013. “Farmers’ willingness to pay for
749 agricultural extension service: evidence from Nigeria.” *Journal of International*
750 *Development* 25:382–392.

751 Parminter, T. 2011. “Past and present history of extension in New Zealand.” In J. R.
752 Jennings, R. G. Packham, and D. Woodside, eds. *Shaping Change: Natural Resource*
753 *Management, Agriculture and the Role of Extension*. Australia: Australasia-Pacific
754 Extension Network (APEN), pp. 23–25.

755 Prager, K., and R. Creaney. 2017. “Achieving on-farm practice change through facilitated
756 group learning: Evaluating the effectiveness of monitor farms and discussion groups.”

Journal of Rural Studies 56:1–11. Available at: https://doi.org/10.1016/j.jrurstud.2017.09.002.

Prager, K., P. Labarthe, M. Caggiano, and A. Lorenzo-Arribas. 2016. "How does commercialisation impact on the provision of farm advisory services? Evidence from Belgium, Italy, Ireland and the UK." *Land Use Policy* 52:329–344. Available at: http://dx.doi.org/10.1016/j.landusepol.2015.12.024.

Pretty, J. 1995. "Participatory learning for sustainable agriculture." *World Development* 23(8):1247–1263.

Pretty, J.N., and R. Chambers. 1993. "Toward a learning Paradigm: New professionalism and institutions for agriculture." In *Rethinking sustainability: Power, knowledge, and institutions*. p. 189. Available at: http://books.google.com/books?hl=en&lr=&id=CwEe9SVExsEC&oi=fnd&pg=PA189&dq=Scaling+up+Conservation+Agriculture+in+Africa+Strategies+and+Approaches&ots=rI8sCCVTNk&sig=q8QocNVhw4M_qz_RQ1dNNmRMUZo#v=onepage&q&f=false.

Pufahl, A., and C.R. Weiss. 2008. "Evaluating the effects of farm programs : Results from propensity score matching." *12th Congress of the European Association of Agricultural Economists-EAAE 2008*:1–11.

Le Quéré, C., R.M. Andrew, J.G. Canadell, S. Sitch, J. Ivar Korsbakken, G.P. Peters, A.C. Manning, T.A. Boden, P.P. Tans, R.A. Houghton, R.F. Keeling, S. Alin, O.D. Andrews, P. Anthoni, L. Barbero, L. Bopp, F. Chevallier, L.P. Chini, P. Ciais, K. Currie, C. Delire, S.C. Doney, P. Friedlingstein, T. Gkritzalis, I. Harris, J. Hauck, V. Haverd, M. Hoppema, K. Klein Goldewijk, A.K. Jain, E. Kato, A. Körtzinger, P. Landschützer, N. Lefèvre, A. Lenton, S. Lienert, D. Lombardozzi, J.R. Melton, N. Metzl, F. Millero, P.M.S. Monteiro, D.R. Munro, J.E.M.S. Nabel, S.I. Nakaoka, K. O'Brien, A. Olsen, A.M. Omar, T. Ono, D. Pierrot, B. Poulter, C. Rödenbeck, J. Salisbury, U. Schuster, J. Schwinger, R. Séférian, I. Skjelvan, B.D. Stocker, A.J. Sutton, T. Takahashi, H. Tian, B. Tilbrook, I.T. Van Der Laan-Luijkx, G.R. Van Der Werf, N. Viovy, A.P. Walker, A.J. Wiltshire, and S. Zaehle. 2016. "Global carbon budget 2016." *Earth System Science Data* 8(2):605–649.

Rejesus, R.M., M.E.M. Mutuc, M. Yasar, A. V. Lapitan, F.G. Palis, and T.T.N. Chi. 2012. "Sending Vietnamese rice farmers back to school: Further evidence on the impacts of

788 farmer field schools." *Canadian Journal of Agricultural Economics* 60(3):407–426.

789 Rosenbaum, P.R., and D.B. Rubin. 1985a. "Constructing a Control Group Using Multivariate
790 Matched Sampling Methods That Incorporate the Propensity Score." *The American*
791 *Statistician* 39(1):33–38.

792 Rosenbaum, P.R., and D.B. Rubin. 1985b. "The Bias Due to Incomplete Matching."
793 *Biometrics* 41(1):103–116.

794 Rougoor, C.W., G. Trip, R.B. m. Huirne, and J.A. Renkema. 1998. "How to define and study
795 farmers' management capacity: Theory and use in agricultural economics." *Agricultural*
796 *Economics* 18(3):261–272.

797 Rubin, D.B. 1974. "Estimating causal effects of treatments in randomized and
798 nonrandomized studies." *Journal of Educational Psychology* 66(5):688–701.

799 Salhofer, K., and G. Streicher. 2005. "Self-selection as a problem in evaluating agri-
800 environmental programs." In *87th EAAE-Seminar. Assessing rural development of the*
801 *CAP*. p. 11.

802 Scotland's Rural College. 2020. "Farming for a better Climate." *Farming for a better*
803 *Climate*. Available at: http://www.sruc.ac.uk/info/120175/farming_for_a_better_climate
804 [Accessed January 10, 2020].

805 Scottish Government. 2019. "Agriculture and the environment: Nitrate Vulnerable Zones."
806 Available at: https://www.gov.scot/policies/agriculture-and-the-environment/nvz/
807 [Accessed February 21, 2019].

808 Scottish Government. 2018. "Economic report on Scottish agriculture 2018 edition."

809 Sewell, A.M., M.K. Hartnett, D.I. Gray, H.T. Blair, P.D. Kemp, P.R. Kenyon, S.T. Morris,
810 and B.A. Wood. 2017. "Using educational theory and research to refine agricultural
811 extension: affordances and barriers for farmers' learning and practice change." *Journal*
812 *of Agricultural Education and Extension* 23(4):313–333.

813 Sharot, T. 2011. "The optimism bias." *Current Biology* 21(23):R941–R945. Available at:
814 http://dx.doi.org/10.1016/j.cub.2011.10.030.

815 Smets, M., T. Morris, and R. Greenwood. 2012. "From practice to field: A multilevel model

of practice-driven institutional change." *Academy of Management Journal* 55(4):877–904.

de Snoo, G.R., I. Herzon, H. Staats, R.J.F. Burton, S. Schindler, J. van Dijk, A.M. Lokhorst, J.M. Bullock, M. Lobley, T. Wrbka, G. Schwarz, and C.J.M. Musters. 2013. "Toward effective nature conservation on farmland: Making farmers matter." *Conservation Letters* 6(1):66–72.

Stuart, E.A. 2010. "Matching methods for causal inference: A review and a look forward." *Statistical Science* 25(1):1–21.

Sutherland, L.A., J. Mills, J. Ingram, R.J.F. Burton, J. Dwyer, and K. Blackstock. 2013. "Considering the source: Commercialisation and trust in agri-environmental information and advisory services in England." *Journal of Environmental Management* 118:96–105. Available at: http://dx.doi.org/10.1016/j.jenvman.2012.12.020.

Tamini, L.D. 2011. "A nonparametric analysis of the impact of agri-environmental advisory activities on best management practice adoption: A case study of Quebec." *Ecological Economics* 70(7):1363–1374. Available at: http://dx.doi.org/10.1016/j.ecolecon.2011.02.012.

The Scottish Government. 2010. *Low Carbon Scotland: Meeting the Emissions Reduction Targets 2010-2022: RPP1*. Available at: http://www.scotland.gov.uk/Resource/Doc/346760/0115345.pdf.

The Scottish Government. 2017. "The draft third report on policies and proposals 2017-2032."

The Scottish Government. 2013. "The second report on proposals and policies."

Thornton, P.H., W. Ocasio, and M. Lounsbury. 2012. *The institutional logics perspective: A new approach to culture, structure and process*. Oxford: Oxford University Press. Available at: http://www.oxfordscholarship.com.ezproxy.is.ed.ac.uk/view/10.1093/acprof:oso/9780199601936.001.0001/acprof-9780199601936.

Tripathi, A., and A.K. Mishra. 2017. "Knowledge and passive adaptation to climate change: An example from Indian farmers." *Climate Risk Management* 16(2017):195–207.

Available at: http://dx.doi.org/10.1016/j.crm.2016.11.002.

Urruty, N., D. Tailliez-Lefebvre, and C. Huyghe. 2016. “Stability, robustness, vulnerability and resilience of agricultural systems. A review.” *Agronomy for Sustainable Development* 36(1):1–15. Available at: http://dx.doi.org/10.1007/s13593-015-0347-5.

Vrain, E., and A. Lovett. 2016. “The roles of farm advisors in the uptake of measures for the mitigation of diffuse water pollution.” *Land Use Policy* 54:413–422. Available at: http://dx.doi.org/10.1016/j.landusepol.2016.03.007.

Walker, B., C.S. Holling, S.R. Carpenter, and A. Kinzig. 2004. “Resilience, adaptability and transformability in social-ecological systems.” *Ecology and Society* 9(2).

Appendix 1. The survey questions for the quantitative evaluation. Only the parts used for this evaluation are included in this appendix.

READ OUT TO RESPONDENT: I would like to invite you to participate in a phone survey conducted by xxx, also known as xxx, which will be carried out by professional interviewers from xxx. The survey seeks to improve our understanding of the implementation of environmental measures in agriculture. This survey is aimed at farmers or farm managers who are involved in the main on-farm decision-making. The survey lasts 20 min, but before I can start the survey I would like to ask you two questions to make sure you are part of the group of farmers we are targeting.

INSTRUCTION INTERVIEWER: CHECK IF RESPONDENT HAS TIME TO PROCEED WITH THE INTERVIEW. OTHERWISE OFFER OPTION TO CALL BACK AT A LATER TIME.

SECTION 1. GENERAL QUESTIONS BEFORE INITIATION OF THE SURVEY

Q.1 Are you a farmer, farm manager or crofter? **SINGLE CODE**

INSTRUCTION INTERVIEWER: WHEN RESPONDENT ANSWERS 'FARMER' (OR FARMER'S WIFE), 'FARM MANAGER' OR 'CROFTER' THEN CODE 'YES'

YES	1
NO	2
DON'T KNOW	98
REFUSED TO ANSWER	99

IF RESPONSE IS YES (CODE 1) CONTINUE WITH SURVEY. OTHERWISE THANK THE RESPONDENT AND ASK FOR CONTACT INFORMATION OF THE MAIN DECISION-MAKER (THE PERSON WHO IS RESPONSIBLE FOR MOST LONG TERM DECISIONS): Unfortunately, this survey is designed to be completed by the person who is a farmer, farm manager or crofter.

Q.2 Are you involved in the main decision-making on the farm? **SINGLE CODE**

Yes	1
No	2
DON'T KNOW	98
REFUSED TO ANSWER	99

IF RESPONSE IS NO (CODE 2) THANK THE PARTICIPANT AND ASK FOR CONTACT INFORMATION OF THE MAIN DECISION-MAKER IN Q2B: Unfortunately, this survey is designed to be completed by the person who is involved in most of the long-term planning decisions.

Q.2B Is someone else in your household responsible for the long-term decision making?

Yes → would it be possible to contact this person now or at a later point in time? (or at a different number)

PROBE INTERVIEWER: THE MAIN DECISION MAKER MIGHT LIVE IN THE SAME

HOUSEHOLD, THEREFORE ASK WHETHER IT IS POSSIBLE TO CONTACT VIA THE SAME NUMBER AT A DIFFERENT TIME, OR WHETHER IT IS EASIER TO CONTACT THIS PERSON AT A DIFFERENT PHONE NUMBER

No → Could provide that person's contact information so we can invite him or her to participate in the survey?

Name …….

Telephone number……..

IF RESPONSE IS YES (CODE 1) CONTINUE WITH SURVEY. READ OUT TO RESPONDENT: Thank you for agreeing to participate in our survey. Your answers will remain strictly confidential and no individual farmer will be identified as having participated in this research. You are free to stop participation or refuse to answer a question at any time. There is no wrong or right answer and if you do not know the answer to a question, you can always respond with 'don't know' or if the question is not applicable to your situation, you can always answer with 'not applicable'.

SECTION 3. PEP QUESTIONS

INTERVIEWER READ OUT: I would now like to ask you questions about Focus Farm discussion meetings organised by xxx.

Q.8 Have you ever participated in xxx discussion meetings organised xxx? **SINGLE CODE**

Yes	1
No	2
Don't know	98
REFUSED TO ANSWER	99

IF YES (CODE 1), PROCEED TO Q.9. IF NO (CODE 2) OR DON'T KNOW (CODE 98), PROCEED TO Q.11

INTERVIEWER READ OUT: in the following questions I will refer to xxx as 'focus farm meetings'

Q.9 Approximately how many times have you attended Focus Farm meetings since 2010? Would you say once, 2-3 times or more than 3 times? **SINGLE CODE**

Once	1
2-3 times	2
More than 3 times	3
NEVER	97
DON'T KNOW	98
REFUSED TO ANSWER	99

PROBE INTERVIEWER WHEN RESPONSE (SPONTANEOUS) IS 'NEVER' (CODE 4): You indicated in the previous question that you have attended climate change focus farm discussion meetings, are you sure your answer is 'never'? **IF YES, GO BACK TO Q.8 AND CHANGE ANSWER. THEN CONTINUE Q.11. IF NO, ASK Q.9 AGAIN AND CONTINUE WITH Q.10.**

READ OUT TO RESPONDENT: I will be reading out a number of questions about the focus farm meetings. Please provide an answer to these questions with 'yes' or 'no'.

THE INTERVIEWER DOES NOT NEED TO READ OUT THE ANSWERS 'YES', 'NO' AND 'DON'T KNOW' FOR EACH QUESTION. READ OUT FOR AT LEAST THE FIRST TWO QUESTIONS AND THEN ONLY READ OUT ANSWER OPTIONS WHEN A RESPONDENT FORGETS OR GIVES A DIFFERENT RESPONSE

INSTRUCTION INTERVIEWER FOR ALL Q.6: IF RESPONSE IS 'SOMETIMES', 'OFTEN' OR A SIMILAR TERM, PLEASE PROBE THE RESPONDENT AND ASK FOR A 'YES' OR 'NO'. IF THE RESPONDENT STAYS WITH HIS ANSWER YOU CAN CODE 'SOMETIMES' OR 'OFTEN' AS 'YES' (CODE 1). IF RESPONSE IS 'RARELY' CODE AS 'NO' (CODE 2)

Q.10a Have you discussed the changes suggested during focus farm meetings with farmers who did not attend the meetings?

YES	1
NO	2
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.10b Have you sought advice from peers or experts whom you have met at focus farm meetings?

YES	1
NO	2
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.10c Were you aware of climate change mitigation measures you could implement on farm before participation in the focus farm meetings?

YES	1
NO	2
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.10d - 1 Have you implemented changes suggested during focus farm meetings on your farm?

YES	1
NO	2
DON'T KNOW	98
REFUSED TO ANSWER	99

IF YES (CODE 1) CONTINUE TO 10.D-2. OTHERWISE CONTINUE WITH Q.11

INTERVIEWER READ OUT: I would like to ask you about the change or changes you have implemented. I will be reading out five key areas of the PEP programme and please identify with either 'yes' or 'no' whether you have implemented changes in this area.

Q.10d – 2 Locking carbon on the farm?

YES	1
NO	2
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.10d – 3 Developing renewable energy?

YES	1
NO	2
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.10d – 4 Using energy and fuel efficiently?

YES	1
NO	2
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.10d – 5 Optimising livestock performance?

YES	1
NO	2
DON'T KNOW	98
REFUSED TO ANSWER	99
NOT APPLICABLE	5 (in survey doc)

Q.10d – 6 Soil, fertiliser and manure management?

YES	1
NO	2

DON'T KNOW	98
REFUSED TO ANSWER	99

SECTION 4. IMPACT INDICATORS

4.1 KNOWLEDGE TEST

READ OUT TO RESPONDENT: I will read out 6 questions about environmentally friendly farm practices. Please answer the question with either 'yes' or 'no'.

NOTE TO INTERVIEWER: THERE IS NO NEED TO READ OUT THE ANSWER OPTIONS 'YES' OR 'NO' FOR EACH QUESTION. READ OUT FOR AT LEAST THE FIRST TWO QUESTIONS AND THEN ONLY TO READ OUT THE ANSWER OPTIONS AGAIN IF THE RESPONDENT DOES NOT REPLY WITH 'YES' OR 'NO'.

Q.11a Do you think regularly servicing of heating devices, such as boilers, saves heating costs?

YES	1
NO	2
NOT APPLICABLE	96
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.11b Do you think insulation of heating devices, such as boilers and hot water tanks, is an effective way of decreasing energy usage?

YES	1
NO	2
NOT APPLICABLE	96
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.11c Do you think a carbon footprint of the farm is useful to identify the largest emissions sources?

YES	1
NO	2
NOT APPLICABLE	96
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.11d Do you think the amount of carbon locked on the farm can be increased by changing how existing woodlands are managed?

YES	1
NO	2

NOT APPLICABLE	96
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.11e Do you think the use of cover crops increases nitrate leaching?

YES	1
NO	2
NOT APPLICABLE	96
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.11f Do you think the soil pH is a relevant factor in calculating fertiliser needs?

YES	1
NO	2
NOT APPLICABLE	96
DON'T KNOW	98
REFUSED TO ANSWER	99

4.2 RENEWABLE ENERGY

READ OUT TO RESPONDENT: The upcoming part focuses on the generation of renewable energy on your farm.

Q.12 Do you receive a subsidy for producing renewable energy on your farm?

Yes	1
No	2
DON'T KNOW	98
REFUSED TO ANSWER	99

READ OUT TO RESPONDENT: I will first ask you questions about the generation of renewable electricity and then about renewable heat.

Q.13 Do you produce renewable electricity on the farm, for instance from wind, solar power, hydro power or biogas?

Yes	1
No	2
DON'T KNOW	98
REFUSED TO ANSWER	99

IF YES CONTINUE WITH Q.14. OTHERWISE CONTINUE WITH Q.19

Q.14a Do you produce renewable electricity from wind?

Yes	1
No	2
DON'T KNOW	98
REFUSED TO ANSWER	99

IF YES (CODE 1) CONTINUE WITH Q.14B. OTHERWISE CONTINUE WITH Q.15

Q.14b. How much renewable electricity was generated by this source in 2016? Please express in kWh.

_____

DON'T KNOW	98
REFUSED TO ANSWER	99

Q.14c. In which year was this source implemented on your farm?

_____

DON'T KNOW	98
REFUSED TO ANSWER	99

Q.15a Do you produce renewable electricity from solar energy?

Yes	1
No	2
DON'T KNOW	98
REFUSED TO ANSWER	99

IF YES (CODE 1) CONTINUE WITH Q.15B. OTHERWISE CONTINUE WITH Q.16

Q.15b. How much renewable electricity was generated by this source in 2016? Please express in kWh.

_____

DON'T KNOW	98
REFUSED TO ANSWER	99

Q.15c. In which year was this source implemented on your farm?

_____

DON'T KNOW	98
REFUSED TO ANSWER	99

Q.16a Do you produce renewable electricity from hydro power?

Yes 1
No 2
DON'T KNOW 98
REFUSED TO ANSWER 99

IF YES (CODE 1) CONTINUE WITH Q.16B. OTHERWISE CONTINUE WITH Q.17

Q.16b. How much renewable electricity was generated by this source in 2016? Please express in kWh.

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

Q.16c. In which year was this source implemented on your farm?

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

Q.17a Do you produce renewable electricity from biogas?

Yes 1
No 2
DON'T KNOW 98
REFUSED TO ANSWER 99

IF YES (CODE 1) CONTINUE WITH Q.17B. OTHERWISE CONTINUE WITH Q.18

Q.17b. How much renewable electricity was generated by this source in 2016? Please express in kWh.

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

Q.17c. In which year was this source implemented on your farm?

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

Q.18a Do you produce renewable electricity from any other source?

Yes 1
No 2

DON'T KNOW 98
REFUSED TO ANSWER 99

IF YES CONTINUE WITH Q. 18B OTHERWISE CONTINUE WITH Q.19

Q.18b Which source?

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

Q.18c How much renewable electricity was generated by this source in 2016? Please express in kWh.

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

Q.18d In which year was this source implemented on your farm?

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

Q.19 Do you produce renewable heat on the farm, for example from biogas or wood pellets?

Yes 1
No 2
DON'T KNOW 98
REFUSED TO ANSWER 99

IF YES (CODE 1), CONTINUE WITH Q.20. OTHERWISE CONTINUE WITH Q.25

Q.20a Do you produce renewable heat from wood logs or chips?

Yes 1
No 2
DON'T KNOW 98
REFUSED TO ANSWER 99

IF YES (CODE 1) CONTINUE WITH Q.20B. OTHERWISE CONTINUE WITH Q.21

Q.20b How much renewable heat was produced by this source in 2016? Please express this amount in kWh.

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

Q.20c. In which year was this source implemented on your farm?

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

Q.21a Do you produce renewable heat from wood pellets?

Yes 1
No 2
DON'T KNOW 98
REFUSED TO ANSWER 99

IF YES (CODE 1) CONTINUE WITH Q.21B. OTHERWISE CONTINUE WITH Q.22

Q.21b How much renewable heat was produced by this source in 2016? Please express this amount in kWh.

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

Q.21c. In which year was this source implemented on your farm?

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

Q.22a Do you produce renewable heat from grass or straw?

Yes 1
No 2
DON'T KNOW 98
REFUSED TO ANSWER 99

IF YES (CODE 1) CONTINUE WITH Q.22B. OTHERWISE CONTINUE WITH Q.23

Q.22b How much renewable heat was produced by this source in 2016? Please express this amount in kWh.

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

Q.22c. In which year was this source implemented on your farm?

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

Q.23a Do you produce renewable heat from biogas?

Yes 1
No 2
DON'T KNOW 98
REFUSED TO ANSWER 99

IF YES (CODE 1) CONTINUE WITH Q.23B. OTHERWISE CONTINUE WITH Q.24

Q.23b How much renewable heat was produced by this source in 2016? Please express this amount in kWh.

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

Q.23c. In which year was this source implemented on your farm?

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

Q.24a Do you produce renewable heat from any other source?

Yes 1
No 2
DON'T KNOW 98
REFUSED TO ANSWER 99

IF YES CONTINUE WITH Q. 24B OTHERWISE CONTINUE WITH Q.25

Q.24b Which source?

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

Q.24c How much renewable heat was produced by this source in 2016? Please express in kWh.

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

Q.24d In which year was this source implemented on your farm?

_____

DON'T KNOW 98
REFUSED TO ANSWER 99

4.3 SOIL NUTRIENT AND ANIMAL MANAGEMENT

READ OUT TO RESPONDENT: I will now ask you some questions about soil nutrient and animal management.

Q.25 Do you conduct soil testing on your fields? **SINGLE CODE.**

Yes 1
No 2
NOT APPLICABLE 96
DON'T KNOW 98
REFUSED TO ANSWER 99

CONTINUE AT Q.26 IF YES (CODE 1). OTHERWISE CONTINUE WITH Q.28

Q.26 How often do you on average conduct soil testing on your fields (Not including rough/mountain grazing and any common land from your estimation)? Would you say yearly, every 2-5 years, or every 6 years or less often? **SINGLE CODE.**

Yearly 1
Every 2 to 5 years 2
Every 6 years or less often 3
DON'T KNOW 98
REFUSED TO ANSWER 99

Q.27 What proportion of your farm did you have soil tested in the past 5 years (exclude rough/mountain grazing and any common land from your estimation)? Would you say less than 25%, 25-75 %, or more than 75 %? **SINGLE CODE**

Less than 25% 1
25 to 75% 2
More than 75% 3
DON'T KNOW 98

REFUSED TO ANSWER..... 99

INTERVIEWER READ OUT: Before asking the next questions, I would like to mention that a nutrient management plan is also known as a fertiliser plan or NMP. This plan can be developed individually or with an advisor and can tell you generally on which fields fertiliser is needed and in what quantities.

Q.28 Do you have a nutrient management plan? **SINGLE CODE**

Yes 1
No..... 2
NOT APPLICABLE..... 96
DON'T KNOW..... 98
REFUSED TO ANSWER..... 99

IF YES (CODE 1) AT Q.28 CONTINUE WITH Q.29. All OTHERS PROCEED TO Q.32

Q.29 Who created your formally developed nutrient management plan? Would that be yourself, an advisor, yourself together with an advisor or someone else? **SINGLE CODE**

Myself..... 1
An advisor 2
Myself and an advisor 3
Other..... 4
DON'T KNOW..... 98
REFUSED TO ANSWER..... 99

WHEN RESPONSE IS 'MYSELF' (CODE 1) OR 'MYSELF AND AN ADVISOR (CODE 3) THEN CONTINUE WITH Q.30, OTHERWISE PROCEED TO Q.31

INTERVIEWER READ OUT: I will read out different information tools. Please identify if you use these tools in the development of your management plan by responding 'yes' or 'no'.

INSTRUCTION: THE INTERVIEWER DOES NOT NEED TO READ OUT THE ANSWERS 'YES' AND 'NO' FOR EACH QUESTION. ONLY READ OUT THE STATEMENT AND REMEMBER THE PARTICIPANT THEY CAN ANSWER 'YES', 'NO' OR 'DON'T KNOW' TO A QUESTION WHEN THEY FORGET OR GIVE A DIFFERENT RESPONSE

30a PLANET? **SINGLE CODE**

YES 1
NO 2

DON'T KNOW 98
REFUSED TO ANSWER 99

30b xxx technical notes? **SINGLE CODE**

YES 1
NO 2
DON'T KNOW 98
REFUSED TO ANSWER 99

30c GPS mapping? **SINGLE CODE**

YES 1
NO 2
DON'T KNOW 98
REFUSED TO ANSWER 99

30d Any other information tool? **SINGLE CODE**

YES 1
NO 2
DON'T KNOW 98
REFUSED TO ANSWER 99

IF YES (CODE 1) CONTINUE TO Q.30D-2. OTHERWISE CONTINUE WITH Q.31

30D-2 Which information tool(s)?

_____

Q.31 Do you apply manure or slurry on your farm? **SINGLE CODE**

Yes 1
No 2
NOT APPLICABLE 96
DON'T KNOW 98
REFUSED TO ANSWER 99

IF YES (CODE 1) CONTINUE WITH Q.32. OTHERWISE CONTINUE WITH Q.34

Q.32 What method do you use to apply manure or slurry? Do you 1: inject it into the soil, 2: band spread it by training hose or shoe, or 3: broadcast? **MULTI CODE**

Inject into the soil 1
Band spread by training horse or shoe 2
Broadcast 3

DON'T KNOW	98
REFUSED TO ANSWER	99

Q.33 How soon after application would you typically plough in manure or slurry? Would you say within 4 hours, between 5 and 6 hours, or after more than 6 hours? **SINGLE CODE**

Within 4 hours	1
Between 5 and 6 hours	2
After more than 6 hours	3
DON'T KNOW	98
REFUSED TO ANSWER	99
NOT APPLICABLE	6 (in survey data)

INTERVIEWER READ OUT: Variable rate application techniques are a precision farming tool. The techniques are used for application of material, such as fertiliser or lime, in a way that the rate of application is based on the precise location of the area that the material is being applied to.

Q.34 Do you use variable rate application techniques when applying nitrogen fertiliser or lime? **SINGLE CODE**

Yes	1
No	2
NOT APPLICABLE	96
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.35 Do you conduct arable farming on your farm? **SINGLE CODE**

Yes	1
No	2
DON'T KNOW	98
REFUSED TO ANSWER	99

IF YES, CONTINUE WITH Q.36. OTHERWISE CONTINUE WITH Q.37

Q.36 Do you include legumes in your crop rotations? **SINGLE CODE**

Yes	1
No	2
DON'T KNOW	98
REFUSED TO ANSWER	99

IF YES (CODE 1) CONTINUE WITH Q.36B. OTHERWISE CONTINUE WITH 37.

Q.36b How often do you include legumes in your crop rotations? Would you say yearly, every 2 to 5 years or every 6 years or less often? **SINGLE CODE**

Yearly	1
Every 2 – 5 years	2
Every 6 years or less often	3
NOT APPLICABLE	96
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.37 Do you have animals on your farm? **SINGLE CODE**

Yes	1
No	2
DON'T KNOW	98
REFUSED TO ANSWER	99

IF YES (CODE 1) CONTINUE TO Q.37B. OTHERWISE CONTINUE WITH Q.42

Q.37b I will now read out different enterprises. Please estimate the total number of animals on your farm in 2017 per enterprise. **MULTICODING ALLOWED, E.G. FARMER CAN OWN DIFFERENT TYPE OF ANIMALS**

Dairy?	
Beef ?	
Sheep?	
Other?	

Q.38a Do you use a mix containing red clover when you reseed your grassland? **SINGLE CODE**

Yes	1
No	2
DON'T KNOW	98
REFUSED TO ANSWER	99
NOT APPLICABLE	5 (in survey)

Q.38b Do you use a mix containing white clover when you reseed your grassland? **SINGLE CODE**

Yes	1
No	2
DON'T KNOW	98

REFUSED TO ANSWER	99
NOT APPLICABLE	5 (in survey)

Q.39 Do you have a herd health plan? **SINGLE CODE**

Yes	1
No	2
NOT APPLICABLE	96
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.40 How often do you consult a vet for non-essential check-ups of your livestock? Would you say never, at least every 6 months, every 7 to 12 months, or less often than annually? **SINGLE CODE**

At least every 6 months	1
every 7 to 12 months	2
Less often than annually	3
NOT APPLICABLE	96
Never	97
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.41 When making decisions on breeding stock, including bull, tup or ram hire, would you say you mainly base your decision on estimated breeding value, preferred traits, costs, or intuition? **MULTI CODE**

Estimated breeding value	1
Preferred traits	2
Intuition	3
Cost	4
NOT APPLICABLE	96
DON'T KNOW	98
REFUSED TO ANSWER	99

SECTION 5. FARM AND FARMER CHARACTERISTICS

READ OUT TO RESPONDENT: We have reached the final section of the survey. I will now ask you some questions about the characteristics of you and your farm. I will start with your characteristics and then continue with the characteristics of the farm.

Q.42 What is your age? **SINGLE CODE**

INSTRUCTION INTERVIEWER Q.42: DO NOT READ OUT THE AGE BANDS, BUT CIRCLE THE AGE CATEGORY THE PARTICIPANT FALLS INTO. IF THEY DO NOT WANT TO SHARE THEIR AGE DIRECTLY, THEN READ OUT AGE BANDS.

UNDER 25	1
25-34	2
35-39	3
40-44	4
45-54	5
55-64	6
65 AND OVER	7
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.43 How many years have you been farming?

INSTRUCTION INTERVIEWER Q.43: DO NOT READ OUT THE BANDS, BUT CIRCLE THE CATEGORY THE PARTICIPANT FALLS INTO

LESS THAN 10 YEARS	1
10 TO 20 YEARS	2
21 TO 30 YEARS	3
MORE THAN 30 YEARS	4
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.44 What describes the highest level of training undertaken? Would you say you have 1: practical agricultural experience only, 2: less than 2 years basic agricultural training, or 3: a full agricultural training course of 2 years or more? **SINGLE CODE**

Practical agricultural experience only	1
Basic agricultural training course – less than 2 years long	2
Full agricultural training course – 2 years long or more	3
DON'T KNOW	98
REFUSED TO ANSWER	99

INTERVIEWER READ OUT: I will now continue with asking about characteristics of your farm.

Q.45 What is the total number of hectares or acres farmed by you in 2017? [This includes rented or leased land] **SINGLE CODE**

____ ha or ____ac

INSTRUCTION INTERVIEWER: IF THEY DO NOT WANT TO MENTION THE EXACT NUMBER, PLEASE READ OUT AREA BANDS

LESS THAN 10 HA (25 ACRES) 1
10-19 HA (25-50 ACRES)……..... 2
20-49 HA (50-123 ACRES)..... 3
50-99 HA (123-247 ACRES) 4
100-149 HA (247-370 ACRES)..... 5
150 HA OR MORE (370 + ACRES)..... 6
DON'T KNOW..... 98
REFUSED TO ANSWER..... 99

Q.46 Is any of this land leased or rented from others? **SINGLE CODE**

Yes 1
No..... 2
DON'T KNOW..... 98
REFUSED TO ANSWER..... 99

IF YES, PROCEED TO Q.47 OTHERWISE CONTINUE WITH Q.48.

Q.47 What is the total number of hectares or acres you rented from others?

____ha or ____ac

INSTRUCTION INTERVIEWER: IF THEY DO NOT WANT TO MENTION THE EXACT NUMBER, PLEASE READ OUT AREA BANDS

LESS THAN 10 HA (25 ACRES) 1
10-19 HA (25-50 ACRES)……..... 2
20-49 HA (50-123 ACRES)..... 3
50-99 HA (123-247 ACRES) 4
100-149 HA (247-370 ACRES)..... 5
150 HA OR MORE (370 + ACRES)..... 6
DON'T KNOW..... 98
REFUSED TO ANSWER..... 99

Q.48 Have you identified a successor to take over the farm? **SINGLE CODE**

Yes 1
No..... 2
DON'T KNOW..... 98
REFUSED TO ANSWER..... 99

Q.49 Which of the following terms best describes the **soil type** of most of your land? Would you say 1: no limitations and suitable for a wide range of agricultural uses, 2: somewhat limited by for instance poor drainage or altitude or 3: very limited by for instance mountain areas? **SINGLE CODE**

Suitable for a wide range of agricultural uses 1
Somewhat limited e.g. by poor drainage or altitude 2
Very limited for agriculture e.g. mountain areas 3
DON'T KNOW..... 98
REFUSED TO ANSWER..... 99

Q.50 Which of the following most closely reflects your major farm activity? Would you say 1: mainly dairying, 2: mainly beef, 3: mainly sheep, 4: mainly arable, 5: mixed livestock, 6: mainly forage or 7: mixed farm? **SINGLE CODE**

Mainly dairying 1
Mainly beef..... 2
Mainly sheep..... 3
Mainly arable 4
Mainly mixed livestock 5
Mainly forage..... 6
Mixed farm 7
DON'T KNOW..... 98
REFUSED TO ANSWER..... 99

Q.51 I would like to ask for your approximate annual farm income before taxes. Please do not include the household income. **SINGLE CODE**

Q.51a Is it below or above £30,000 per annum (£580 per week)?

BELOW 1
ABOVE 2
DON'T KNOW 98
REFUSED TO ANSWER 99

IF BELOW (CODE 1) CONTINUE WITH Q.51B. IF ABOVE (CODE 2) CONTINUE WITH Q.51D.

Q.51b Is it below or above £20,000 per annum (£385 per week)?

BELOW	1
ABOVE	2
DON'T KNOW	98
REFUSED TO ANSWER	99

IF BELOW (CODE 2) CONTINUE WITH Q.51C. IF ABOVE (CODE 2) CONTINUE WITH Q.52

Q.51c Is it below or above £10,000 per annum (£195 per week)?

BELOW	1
ABOVE	2
DON'T KNOW	98
REFUSED TO ANSWER	99

FOR BELOW AND ABOVE (CODE 1 AND 2) CONTINUE TO Q.52

Q.51d Is it below or above £40,000 per annum (£770 per week)

BELOW	1
ABOVE	2
DON'T KNOW	98
REFUSED TO ANSWER	99

IF BELOW (CODE 1) CONTINUE WITH Q.52. IF ABOVE (CODE 2) CONTINUE WITH Q.51E

Q.51e Is it below or above £50,000 per annum (£960 per week)

BELOW	1
ABOVE	2
DON'T KNOW	98
REFUSED TO ANSWER	99

Q.52 What is the agricultural holding number of your farm? **INSTRUCTION INTERVIEWER: MOST FARMERS WILL NOT MENTION THE FIRST TWO DIGITS AND THE CODES MAY DIFFER IN LENGTH, SO NOT ALL THE 9 DIGITS WILL BE MENTIONED.**

_ _ / _ _ _ / _ _ _ _

DON'T KNOW	98
REFUSED TO ANSWER	99

Q.53 What is your post code?

_____

DON'T KNOW	98
REFUSED TO ANSWER	99

INTERVIEWER READ OUT: Thank you for participating in our survey. In the future we might like to conduct follow-up research, therefore I would like to ask whether you are willing to participate in a follow-up survey? **SINGLE CODE**

Q.54

Yes	1
No	2
DON'T KNOW	98
REFUSED TO ANSWER	99

INTERVIEWER READ OUT: This is the end of the survey. Thank you for participating.

INSTRUCTION TO INTERVIEWER: AFTER EACH INTERVIEW NOTE DOWN THE FOLLOWING (DO NOT ASK THIS TO THE RESPONDENT):

Extra details respondent	Answer
Caller ID of respondent	
Gender of respondent	
Number of attempt	
Duration of the interview in minutes and seconds	
Starting time of the interview	
Date the interview took place	

1636 **Appendix 2. Overview of the 20 respondents included in the interviews**

Respondent	Area	Years of experience	Agricultural education	Size of farm (ha)	Rented land (yes/no)	Successor (yes/no)	Soil type	Type of farm	Nr of meetings (as indicated in survey)	Nr of meetings (as indicated in interview
1	Scottish borders	>30	Yes (full)	194	no	yes	very limited	mixed farm	>3	>3
2	Scottish borders	>30	Yes (full)	500	no	no	suitable	mixed livestock	>3	>3
3	East Lothian	21-30	Yes (full)	170	yes	no	limited	arable	>3	>3
4	Angus	>30	Yes (full)	165	no	yes	suitable	arable	>3	>3
5	Angus	>30	Yes (full)	300	no	no	suitable	arable	2 to 3	?
6	Aberdeenshire	21-30	Yes (full)	15	yes	yes	limited	mixed livestock	2 to 3	2 to 3
7	Aberdeenshire	21-30	Yes (full)	29	no	no	limited	arable	2 to 3	?
8	Aberdeenshire	>30	no (practical experience)	202	no	yes	suitable	mixed farm	2 to 3	2 to 3
9	Aberdeenshire	>30	Yes (full)	60	no	no	limited	forage	>3	>3
10	East Ayrshire	>30	Yes (full)	220	yes	yes	limited	mixed livestock	>3	>3
11	East Ayrshire	21-30	Yes (full)	240	yes	no	limited	dairy	2 to 3	2 to 3

12	Dumfries and Galloway	21-30	Yes (basic)	52	no	no	suitable	forage	>3	>3
13	Stirling	>30	Yes (full)	160	no	yes	limited	dairy	>3	?
14	Fife	21-30	Yes (basic)	242	yes	no	limited	mixed farm	2 to 3	2 to 3
15	Aberdeenshire	21-30	Yes (basic)	2226	yes	no	limited	mixed farm	>3	2 to 3
16	Aberdeenshire	21-30	Yes (full)	53	yes	no	suitable	mixed farm	>3	>3
17	Aberdeenshire	>30	Yes (full)	440	yes	no	limited	beef	2 to 3	2 to 3
18	Fife	21-30	Yes (full)	250	yes	yes	suitable	dairy	>3	>3
19	Midlothian	21-30	yes (full)	11000	yes	no	suitable	mixed farm	>3	2 to 3
20	Eastlothian	>30	yes (full)	360	no	yes	suitable	mixed farm	2 to 3	?

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Appendix 3. Overview of the questionnaire used for the qualitative analysis

- Could you please describe your role on the farm?
- How would you describe your type of farm?
- How many ha is the farm you are farming on? (how much is owned/how much is leased?)
- how many employees do you have?
- What is the herd size?
- Are you a member of a farming group? E.g. discussion groups
    - for each of the groups mentioned: how often have you met them over the past year?
- How would you describe your experience working on this specific farm and in the farming sector in general?
- How would you describe the management of the farm (governance)?
    - if multiple people are involved in management: who is responsible for which decision-making?
- How much longer do you intend to be on the property?
    - Do you have a successor?
- Do you receive any subsidies?
    - if yes, what type of subsidies? (e.g. based on voluntary participation etc.)
- What are your goals/aspirations for the farm?
    - Are these any different to what they were 5-10 years ago?

I would like to gain insight into how you have experienced meetings of the PEP.

- Which focus farm did you visit mostly?
- Can you describe how you have experienced your participation in the programme?
- Can you describe why you attended the meetings?
- About the structure of the meeting:
    - Can you describe what the meetings looked like?
    - Did you have the opportunity to raise your own issues or share experiences?
    - Did you have discussion at the meeting in small groups?
- About peers
    - Please describe the nature of the interaction with peers during the meetings?

- Did you know any of the other participants of the meeting?
- Have you met with any other farmers at the meetings more than once?
- What type of information did you share about your farm? What did others share?
- Did you discuss with any of your peers outside the meetings?

- About the facilitator
  - Please describe the nature of the interaction with the facilitator during the meetings?
  - Would you consider going to meetings with the same facilitator again? Why?
  - Would you take up changes if recommended by the facilitator?
- About the experts
  - Please describe the nature of the interaction with the experts during the meetings?
  - How credible was the information presented by the experts?
- About how they feel their thinking has changed
  - To what extent did participating change your concerns about the topics discussed?
  - The most interesting thoughts were rather from peers, or the facilitator, or the experts?
  - Have you experimented with any of the suggested practices?
  - Can you name any other changes you have made due to participation in the programme?
  - What aspect of the programme stimulated you to make this change?

Appendix 4. Overview of the data for the quantitative evaluation

Table 1. Variable description and descriptive statistics of the sample before matching. The means and standard deviation are depicted in parentheses. The indicated significance levels in the column 'PEP 2010-2013' indicate differences in covariates between PEP 2010-2013 farmers and control farmers (Comparison I). In the column 'PEP 2014-2017' the differences between PEP 2014-2017 farmers and control farmers are indicated (Comparison II). *,**,* Significant at 0.1%, 1%, 5% level, respectively**

		Farmer categories		
		PEP 2010-2013 farmers	**PEP 2014-2017 farmers**	**Control farmers**
	Description	(n=36)	(n = 114)	(n = 190)
Explanatory variables				
Years of experience	Years of experience as farmer, where 0 = 0 years, 1 = 1 to 10 years, 2 = 11 to 20 years, 3 = 21 to 30 years, 4 = 31 or more	3.30 (1.00)	3.31 (0.98)	3.32 (0.98)
Agricultural education	is 1 if farmer has agricultural education	0.50*** (0.50)	0.55 ***(0.50)	0.44 (0.50)
Size	amount of land (ha) farmed in 2016	303.02 (1688.28)	384.76 (1655.33)	298.37 (1837.30)
Rented land	is 1 if farmer has land rented from others	0.39 (0.49)	0.42* (0.50)	0.38 (0.49)
Successor	is 1 if farmer has a successor	0.41 (0.49)	0.43 (0.50)	0.42 (0.50)
Soil type	is 1 if soil type is limited	0.42 (0.50)	0.47*** (0.50)	0.41 (0.49)

Livestock on farm	is 1 if livestock is present on farm	0.56 (0.50)	0.53 (0.50)	0.56 (0.50)
Outcome variables				
Production of renewable electricity	Is 1 if farmer is producing renewable electricity	0.25*** (0.43)	0.28*** (0.45)	0.20 (0.40)
Production of renewable heat	Is 1 if farmer is producing renewable heat	0.16*** (0.37)	0.17*** (0.38)	0.12 (0.33)
Implementation of nutrient management plan	Is 1 if farmer has implemented a nutrient management plan	0.46 (0.50)	0.59*** (0.49)	0.44 (0.46)
Soil testing	Is 1 if farmer conducts soil testing	0.74*** (0.44)	0.81*** (0.40)	0.69 (0.46)
Knowledge acquisition	Knowledge acquisition measured by amount of questions correctly answered, where 0 represents no questions correctly answered and 6 represents all questions correctly answered	4.52*** (1.13)	4.62*** (1.08)	4.47 (1.12)

Table 2. Propensity score estimates for Comparison I and Comparison II. *,**,* Significant at 0.1%, 1%, 5% level, respectively.**

	Comparison I	**Comparison II**
Variable		
Years of experience	-0.26 (0.20)	-0.09 (0.13)
Agricultural education	1.63 (0.46) ***	1.18 (0.27) ***
Size	0.00 (0.00)	0.0001 (0.00)
Rented land	0.01 (0.41)	0.24 (0.26)
Successor	-0.33 (0.41)	0.15 (0.26)
Soil type	0.36 (0.39)	0.63 (0.26) *
Livestock	-0.19 (0.40)	-0.52 (0.25) *
Number of observations	226	304
Pseudo R^2	0.094	0.092
Log-likelihood	-89.82	-182.45
LR chi-square	18.58 **	37.32 ***

AIC	195.64	380.91

Table 3. Assessment of matching quality. LR refers to likelihood ratio.

	Comparison I		**Comparison II**	
	2010-2013	Control	2014-2017	Control
Variable				
Years of experience	3.19	3.22	3.31	3.25
Agricultural education	0.78	0.75	0.73	0.67
Size	327.57	197.22	535.61	401.82
Rented land	0.44	0.47	0.5	0.47
Successor	0.33	0.3	0.44	0.41
Soil type	0.53	0.55	0.56	0.49
Livestock	0.56	0.58	0.48	0.51
Pseudo R^2	0.05		0.01	
LR chi-square	4.95		3.44	